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(54) Method and apparatus for treating or utilizing a hot gas flow.

(57) A method and apparatus for cooling hot gas in a reactor (10) which is provided with a mixing chamber (12) for hot gas and a chamber encompassing a bubbling fluidized bed (11) in the lower section of the reactor, a riser (14) in the middle section, a gas outlet (18) in the upper section of the reactor, and heat transfer surfaces for recovering heat from solid particles. The hot gas is introduced through the mixing chamber (12) into the lower section of the reactor. In the mixing chamber (12) solid particles are supplied to the hot gas for cooling the gas. The gas containing solid particles is conveyed into a separator, where a portion of the solid particles is separated from the gas and flows into the fluidized bed (11). From the separator, the gas is conveyed through the riser into particle separators (17) and, when purified, further out of the reactor (10). The solid particles separated in the particle separator (17) are returned to the lower section of the reactor. From the fluidized bed (11), cooled solid particles are conveyed to the mixing chamber (12) for cooling of hot gas.

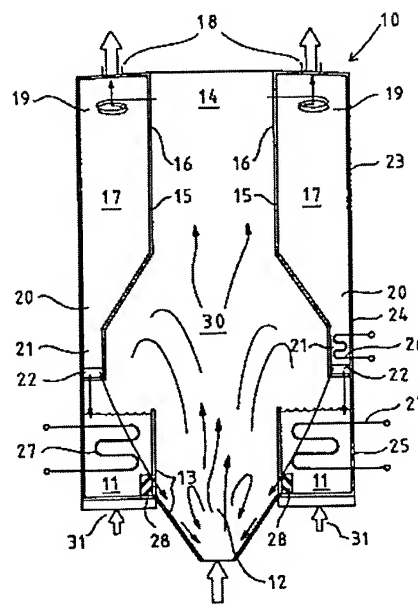

FIG. 1

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The present invention relates to a method and apparatus for cooling or utilizing hot gas in a reactor which is provided with a hot gas inlet and a chamber encompassing a fluidized bed in the lower section of the reactor, a riser, and a gas outlet in the upper section of the reactor. The invention also relates to a method, in which solid particles are separated from a cooled gas containing solid particles, and these separated solid particles are returned to the lower section of the reactor for recovering heat therefrom, and the cooled gas is discharged from the reactor via the gas outlet.

Fluid bed reactors are well applicable to cooling of hot gases containing molten and/or vaporized components and/or tar-like particles. Gas coolers are suited to, e.g., cooling of exhaust gases from industrial plants and dry purification of gases containing dust and tar and other condensing components, which gases have resulted from partial oxidation of biomass, peat or coal. The hot gases introduced into the reactor are efficiently cooled by mixing solid particles therewith, such solid particles having been cooled in the reactor earlier.

Finnish patent 64997 teaches cooling of hot gases in circulating fluidized bed reactors. Here hot gases are fed as fluidizing gas into the mixing chamber of the reactor, where the gases cool efficiently as they come into contact with a large amount of solid particles, i.e., bed material. Solid particles are carried by the gas flow through the riser into the upper section of the reactor, where they are separated and then returned to the fluidized bed in the mixing chamber. In the riser, the gas flow conveying solid particles is cooled by heat transfer surfaces.

A drawback of the method described above is, however, that the hot gases to be cooled have to fluidize a large amount of solid particles, whereby the power requirement is high. Furthermore, especially the chlorine-containing gases cause corrosion in hot conditions and, therefore, superheating of steam to high temperatures is not usually possible in the heat transfer surfaces of the riser, whereas SO_3-containing gases may cause problems with the heat transfer surfaces at low temperatures.

In the method described above, the riser is considered a natural place for the heat transfer surfaces because the solids and gas flows are swift therein. The gas stream, may, however, cause wear of the heat transfer surfaces in the riser, especially in the lower section of the heat exchangers arranged in the riser. Wear is attributable to the high hitting velocity of the dust entrained with the gas against the surfaces.

Finnish patent application 913416 teaches cooling of hot process gas in a stationary fluidization, i.e., a so-called bubbling fluidized bed. Here the hot gas flowing into the reactor is supplied with solid particles as an overflow from the bubbling fluidized bed. The gas and the solid particles entrained therewith flow into a dust collecting chamber disposed above the bubbling fluidized bed, wherefrom solid particles then drop back onto the surface of the bubbling fluidized bed as the flow rate of the gas decreases. The bubbling fluidized bed and the gas riser, which is disposed above the dust collecting chamber, are provided with heat transfer surfaces.

In the arrangement described above, the particles fallen onto the surface of the bubbling fluidized bed are fast carried along the surface back to the overflow point, where they are immediately taken to recirculation ending up in the dust collecting chamber. Thus, a separate "surface circulation" of hot particles is developed above the fluidized bed. These particles do not cool efficiently in the fluidized bed because the particles which are deeper down in the fluidized bed, near the heat transfer surfaces, cannot mix efficiently with the particles present in the "surface circulation".

In the arrangement of FI patent application 913416, due to, e.g., the effect of the above-mentioned "surface circulation", a sufficiently effective and fast cooling of gases is not achieved. Neither is so dense particle suspension produced in the gas inlet duct that efficient cooling of the gas would be possible. So, in some cases, the hot gas flowing to the reactor may cause fouling and clogging of the heat transfer surfaces when the gas may enter the heat transfer surfaces too hot. If the hot gas does not cool until it touches the heat transfer surfaces, the impurities will correspondingly condense on or adhere to these surfaces, and not on the circulating mass particles as is normally intended. Thus, the prior art offers many problems to be solved.

It is an object of the present invention to provide an improved method and apparatus, when compared with the above-described ones, for cooling or utilizing hot gases in the hot gas treatment of solid material.

It is especially an object to provide a method and apparatus for minimizing power consumption and wear of the heat transfer surfaces.

It is a further object of the present invention to provide a method and apparatus by means of which the heat energy released by the hot gas when it cools may be utilized as efficiently as possible, e.g., for generation of superheated steam without a substantial risk of corrosion.

It is a still further object of the invention to provide a method and apparatus for substantially decreasing the corrosion of the heat transfer surfaces caused by components, such as chlorine, contained in the gas, and thus utilizing more efficiently the heat energy released by the hot gas

when it cools, for example, for the generation of superheated steam.

It is a still further object of the invention to provide a method and apparatus for fast and effective cooling of the gases.

For achieving the above objects, it is characteristic of the method of the invention for cooling a hot gas in a fluidized bed reactor that

- solid particles entrained with the gas are separated from the gas in a particle separator arranged in operational communication with the upper section of the reactor, and that
- the lower section of the reactor is provided with a mixing chamber, where a fluidized bed is maintained.

Correspondingly, it is characteristic of the apparatus of the invention for cooling a hot gas in a bubbling fluidized bed reactor that the reactor comprises

- a mixing chamber arranged in the lower section of the reactor, below the riser, for mixing gas with solids,
- at least one particle separator,
- at least one return duct for returning the particles separated in the particle separator to the lower section of the reactor, and
- heat transfer surfaces arranged in the fluidized bed.

According to a preferred embodiment of the invention, solid particles are preferably conveyed from the fluidized bed through the solids openings arranged in the lower section thereof into the hot gas flow in the mixing chamber, in the wall between the mixing chamber and the fluidized bed. Due to a higher static pressure in the fluidized bed, solid material may be arranged to flow automatically through the openings into the hot mixing chamber, but the solids flow may also be regulated by feeding fluidizing gas into the openings, which prevents flowing of the gas from the mixing chamber to the fluidized bed against the flow direction of the solids. In this way, it is possible to regulate the flow of solid particles.

In the reactor according to the invention, hot gas is cooled to a substantially lower temperature immediately at the mixing chamber by mixing cooled solid particles with the gas, whereby the gas cools and the solid particles are correspondingly heated. Besides cooling of gases, the invention may be employed in processes where solid material is heated or otherwise treated with hot gases, such as, e.g., heating of lime with hot gases.

In a reactor according to a preferred embodiment of the invention, gas may also be cooled by constructing the mixing chamber and the riser of cooled surfaces. Solid particles are separated from the gas in a particle separator. The solid particles are conveyed as a dense suspension, almost as a plug flow if desired, via the return duct back to the lower section of the reactor. In the return duct is preferably disposed heat recovery surfaces for recovering the heat energy released by heated solid particles. According to the invention, solid particles are returned to the mixing chamber in the lower section of the reactor, into the gas to be cooled. The return duct is preferably arranged with means for leading the returning solid particles to the mixing chamber and fluidized bed.

Proper control of the circulating solids flow improves the controllability and increases the reaction velocity of the process. Furthermore, the circulating fluidized bed maintains the reactor surfaces clean, ensuring that clogging does not occur, whereby cooling of the gas is always certain when the cooling of the solids functions reliably.

The return duct is a favourable location for heat transfer surfaces because the particle density is relatively high there, which is beneficial in respect of heat transfer. Neither does hot gas containing molten or condensing components, which might clog the heat transfer surfaces, substantially flow into the return duct.

Heat transfer surfaces may also be disposed in the fluidized bed itself, where flowing is slow and thereby favourable for the durability of the heat transfer surfaces. Also such gas that provides favourable conditions, e.g., inert gas, air, or other gas containing non-corroding substances, may be supplied to the fluidized bed as a fluidizing gas. Also heat exchange is efficient due to a high particle density.

The method and apparatus according to the invention provides efficient mixing of solids and hot gas and, consequently, efficient heat exchange from the gases to the solid material. Furthermore, the method and apparatus according to the invention provides a simple arrangement for minimizing wear of the heat transfer surfaces in the gas cooler. At the same time, power consumption is capable of being lowered in comparison with other arrangements used. Furthermore, in the arrangement according to the invention, the heat energy released by the gases is well utilized, e.g., by generating superheated steam.

The invention will be described in more detail, by way of example, with reference to the accompanying drawings, in which

Fig. 1 is a schematic illustration of a reactor arrangement according to the invention;

Fig. 2 is a schematic illustration of a second reactor arrangement according to the invention; and

Fig. 3 is a schematic side view of the lower section of Fig. 2.

Fig. 1 illustrates a reactor 10 for cooling or utilizing hot process gases. The reactor 10 comprises a chamber in the lower section thereof. The chamber has an open top and is provided with a bubbling fluidized bed. Inside the chamber is provided a mixing chamber 12 which has an open top and which is substantially defined by walls 13 separating the mixing chamber 12 from the fluidized bed 11. The mixing chamber has an upwardly widening lower section whereinto hot gases are fed. The walls 13 of the mixing chamber may be constructed of cooling panels for recovering of heat. The fluidized bed reactor may be either annular or rectangular in shape. In the former case the fluidized bed preferably encircles the mixing chamber 12 and in the latter case the fluidized bed 11 is arranged adjacent to at least one wall 13 of the rectangular mixing chamber. In the arrangement of Fig. 1, the mixing chamber is encircled by the fluidized bed.

On top of the mixing chamber 12 and partly on top of the fluidized bed 11 is arranged a preseparation chamber 30. The cross section of the bottom of the preseparation chamber is larger than the cross section of the mixing chamber 12. Above the preseparation chamber is disposed a riser 14 which is preferably defined by cooling panels 15. The upper part of the riser is provided with openings 16, which bring the riser into communication with particle separators 17, which are structurally integrated with the riser.

The particle separators 17 are arranged adjacent to the upper part of the riser 14, the walls 15 of the riser preferably forming part of the wall surface of the particle separators. The particle separators are preferably cyclone separators, where gas outlets 18 and inlet opening 16 provide a vortex flow 19 per each outlet. The lower section 20 of the particle separator 17 is in communication with a return duct 21, which, according to Fig. 1, comprises means 22 for distributing the flow of solid particles into partial flows. Solid particles are returned to the mixing chamber 12. The return duct 21 preferably connects the particle separator also with the fluidized bed 11. The return duct preferably forms a slot-shaped duct in connection with the lower section of the riser, and the wall 15 of the preseparation chamber 30 or riser 14 preferably constitutes a wall of the return duct. The outer wall 23 of the particle separator, outer wall 24 of the return duct and outer wall 25 of the fluidized bed 11 may all be of one and the same construction, e.g., membrane panel.

The return duct 21 is preferably provided with heat transfer surfaces 26. Also the fluidized bed 11 is preferably provided with heat transfer surfaces 27.

The reactor functions so that hot gas is introduced into the lower section of the reactor, which hot gas is mixed with cooled solid particles in the fluidized bed arranged in the mixing chamber 12. The hot gas cools very quickly by releasing heat energy to solid particles and, in a short time, it reaches such a temperature level at which the components, such as tars, impeding the progress of the process no longer affect the course of process.

The gas and solid particles entrained therewith flow as a suspension upwardly into the preseparation chamber 30. The cross section of the preseparation chamber is larger than that of the mixing chamber 11. Hence, a portion of the particles flowing upwardly entrained with the gases loses their speed and starts to flow by gravity into the fluidized bed 11. The gas suspension flows through the riser and further from its upper part via opening 16 into the particle separator 17, where solid particles are separated from the gas. Purified and cooled gases are led out of the reactor through the outlet 18. According to need, there may be one or more particle separators.

The separated solid particles are allowed to flow by gravity downwardly in the return duct 21. Solid particles cool when releasing part of their heat energy in the heat exchanger 26 or to the heat exchangers (not shown) disposed in the walls of the reactor construction. In the arrangement of Fig. 1, cooled solid particles are returned to the mixing chamber 12, but a portion of the solid particles may be conveyed from the particle separator 17 through the return duct 21 also into the fluidized bed 11.

Appropriate fluidizing, in respect of heat transfer, is maintained in the fluidized bed 11 by leading fluidizing air or fluidizing gas through means 31 into the fluidized bed. Favourable conditions for the heat transfer surfaces may be arranged in the fluidized bed, e.g., by choosing a suitable fluidizing gas for eliminating, e.g., corroding conditions form the fluidized bed. The fluidizing gas may be, e.g., inert gas, purified process gas or air. The amount of solid particles in the reactor may be adjusted by adding or removing particles according to need. From the lower section of the fluidized bed 11, solid particles are conveyed through means 28 disposed in the wall 13 into the mixing chamber 12. The carrying force is the pressure difference prevailing between the fluidized bed 11 and the mixing chamber 12. The motion of the solid particles may be adjusted by feeding gas to means 28 or by fluidizing the bed, thereby intensifying the motion of the solid particles. The particles flowing into the mixing chamber are immediately mixed with the fluidized bed in the mixing chamber and also with the hot gas, and a portion of the particles

is carried with the hot gas up into the riser 14. So, in the mixing chamber is also provided a fluidized bed, which comprises a substantially vertical flow of the suspension of gas and particles, produced above the gas inlet, and a particle flow moving along the walls 13 of the mixing chamber parallel therewith and towards the gas inlet.

The arrangement shown in Fig. 1, in which the reactor 10 and the essential parts thereof are either annular or round in cross-sectional area, allows an implementation in which the reactor structure is square or rectangular. In that case, the cross section of the mixing chamber 12 of hot gases has the shape of an elongated slot. Correspondingly, the cross section of the riser 22 has the shape of a rectangle, and the fluidized bed 11 is arranged in two chambers which are of the same length as the substantially rectangular mixing chamber 12 and which are disposed on both sides thereof. In this embodiment, the particle separators 17 are also rectangular in cross section, and they are parallel with the riser and arranged on both sides thereof.

Figs. 2 and 3 illustrate a reactor 210 for cooling or utilizing hot process gases. The reactor 210 comprises a chamber in the lower section thereof. The chamber has an open top and is provided with a bubbling fluidized bed 211, 311, as in the side view in Fig. 3. Inside the chamber is provided a mixing chamber 212, 312 which has an open top and which is substantially defined by walls 213, 313 separating the mixing chamber 212, 312 from the chamber 211, 311. The mixing chamber has an upwardly widening lower section whereinto hot gases are fed. The walls 213, 313 of the mixing chamber may be constructed of cooling panels for recovering of heat. The fluidized bed reactor is angular in shape, and the fluidized bed 211, 311 is preferably arranged adjacent to at least one wall 313 of the rectangular mixing chamber.

The upper section of the riser 214 is provided with an opening 216, which brings the riser into communication with the particle separator 217 structurally integrated with the riser. The particle separator 217 is arranged adjacent to the upper part of the riser 214. The lower section 220 of the particle separator 217 is in communication with a return duct 221, which, according to Fig. 2 comprises means 222 for distributing the flow of solid particles into partial flows. Solid particles are returned to the mixing chamber 212. The return duct 221 preferably connects the particle separator also with the fluidized bed 211.

The return duct 221 is preferably provided with heat transfer surfaces 226. Also the fluidized bed 211 is preferably provided with heat transfer surfaces 226, 326. In accordance with the invention, the gas mixing chamber may be rectangular in cross section, in which mixing chamber at least two opposite walls are outward inclined when seen from bottom to top, whereby the bubbling fluidized bed is preferably arranged in an elongated chamber, which has an open top and which is disposed adjacent to the mixing chamber. The mixing chamber may be defined of substantially four walls so that the substantially vertical walls of the mixing chamber are provided with an inlet/inlets for solid material. The bubbling fluidized bed is preferably provided with means 228 for conveying solid particles from the bed via inlet openings into the mixing chamber.

The reactor shown in Figs. 2 and 3 functions in the same way as the reactor shown in Fig. 1. Hot gas is introduced into the lower section of the reactor, which hot gas is mixed with cooled solid particles in the mixing chamber 212, 312. The hot gas cools very quickly by releasing heat energy to solid particles and, in a short time, it reaches such a temperature level at which the components, such as tars, impeding the progress of the process no longer affect the course of process.

The gas and solid particles entrained therewith flow as a suspension upwardly into the preseparation section 231. The cross section of the preseparation section is larger than that of the mixing chamber 212. Hence, a portion of the particles flowing upwardly entrained with the gases loses their speed and starts to flow by gravity into the fluidized bed 211, 311. The gas suspension flows through the riser and further from its upper part via opening 216 into the particle separator 217, where solid particles are separated from the gas. Purified and cooled gases are led out of the reactor through the outlet 218.

The separated solid particles are allowed to flow by gravity downwardly in the return duct 221. Solid particles cool when releasing part of their heat energy in the heat exchanger 226 or to the heat exchangers (not shown) disposed in the walls of the reactor construction. In the arrangement of Figs. 2 and 3, cooled solid particles are returned to the mixing chamber 212, but a portion of the solid particles may be conveyed from the particle separator 217 through the return duct 221, guided by means 222, also into the fluidized bed 211, 311. Solid material is introduced into the fluidized bed from the return duct via opening 330 and into the mixing chamber via opening 229, 329, which openings are here, for the sake of simplicity, shown round.

Appropriate fluidizing, in respect of heat transfer, is maintained in the fluidized bed 211 by leading fluidizing air or fluidizing gas through means 327 into the fluidized bed. From the lower portion of the fluidized bed 211, 311, solid particles are conveyed through means 328, disposed in the wall 213, 313, into the mixing chamber 312. A portion of

the solid particles may be taken out of the process by means 331. Then, new material is brought to the process, e.g., into the return duct (not shown). The carrying force in leading the solid particles into the mixing chamber 312 is preferably the pressure difference prevailing between the fluidized bed 211, 311 and the mixing chamber 212, 312. Means 328 preferably serve as the adjusting means of the solids flow and as a loop seal, preventing the gas flow from the mixing chamber into the fluidized bed. Particles flowing into the mixing chamber are there immediately mixed with the fluidized bed, into which hot gas is introduced. From the mixing chamber, the particles are carried with the hot gas up into the preseparation chamber 231 and a portion of the particles further into the riser 214.

The fluidized bed may also be divided into several, separate beds, i.e. partial beds, whereby it is possible to operate at different temperatures in different partial beds. Thus, one partial bed may have e.g. superheating surface and a high bed temperature, e.g., 600 °C, and another, e.g. vaporizing surface and a lower bed temperature, e.g., 350 °C.

The riser is preferably so arranged that its free flow cross section is smaller than that of the preseparation chamber. This may be arranged simply so that the cross section of the flow duct is made smaller than that of the preseparation chamber or alternatively so that the riser is provided with heat transfer surfaces 232, which consume space in the duct, whereby the real flow cross section becomes smaller.

The riser 14, 214 may also be constructed as a so-called fire tube type, in which the suspension of gas and particles flows in substantially vertical ducts or tubes, encircled by a heat transfer medium, such as air.

It is not an intention to limit the invention to the examples described above, but, on the contrary, to apply it to different modifications within the scope of invention defined by the accompanying claims.

Claims

1. A method of cooling hot gas in a reactor (10, 210) provided with a hot gas inlet duct and a chamber encompassing a fluidized bed (11, 211, 311) in the lower section of the reactor, a riser (13, 214), and a gas outlet (18, 218) in the upper section of the reactor, whereby
   - hot gas is introduced into the lower section of the reactor,
   - solid particles from the bubbling fluidized bed (11, 211, 311) are introduced into the hot inlet gas for cooling thereof,
   - solid particles are separated from the cooled, solids-containing gas in a preseparation chamber and particles are returned to the fluidized bed,
   - heat is recovered from the solid particles in the fluidized bed (11, 211, 311),
   - gas is discharged from the upper section of the reactor via the gas outlet (18, 218),

   characterized in that
   - solid particles entrained with the gas are separated from the gas in a particle separator (17, 217) arranged in operational communication with the upper section of the reactor, and that
   - the lower section of the reactor is provided with a mixing chamber, where a fluidized bed is maintained.

2. A method as recited in claim 1, **characterized in that** the temperature of the fluidized bed maintained in the mixing chamber is regulated to a lower level than the temperature of the hot gas introduced into the mixing chamber.

3. A method as recited in claim 1, **characterized in that** the temperature of the fluidized bed maintained in the mixing chamber is regulated to a lower level than the temperature of the hot gas introduced into the mixing chamber, by bringing solid particles at a temperature lower than that of the fluidized bed into the fluidized bed.

4. A method as recited in claim 1, **characterized in that** solid particles separated in the particle separator (17, 217) are cooled and returned through the return duct (21, 211) into the mixing chamber (11, 212, 312) arranged in connection with the reactor inlet duct.

5. A method as recited in claim 1, **characterized in that** the gas flow is conveyed from the riser into at least one particle separator, wherefrom separated solid particles are returned via at least return duct.

6. A method as recited in claim 1, **characterized in that** from the lower section of the fluidized bed, solid particles are introduced into hot gases through means disposed in the wall between the fluidized bed and the mixing chamber.

7. A method as recited in claim 6, **characterized in that** the means serve as a loop seal and/or adjusting means for the flow of solid particles.

8. A method as recited in claim 1, **characterized in that** solid particles are cooled on heat transfer surfaces disposed in the return duct.

9. A method as recited in claim 1, **characterized in that** solid particles are cooled on heat transfer surfaces in the bubbling fluidized bed.

10. A method as recited in claim 1, **characterized in that** the gas containing solid particles us cooled on the heat transfer surfaces of the riser.

11. A method as recited in claim 1, **characterized in that** the gas containing solid particles is cooled on the heat transfer surfaces of the wall structure of the mixing chamber.

12. A method as recited in claim 1, **characterized in that** the hot gas is introduced into the mixing chamber of the reactor so that a fluidized bed is formed in the mixing chamber, which fluidized bed comprises a substantially vertical flow of the suspension of gas and particles, produced above the gas inlet, and a flow of particles flowing along the walls of the mixing chamber parallel therewith.

13. A method as recited in claim 1, **characterized in that** a portion of the solid particles separated in the particle separator is returned to the fluidized bed.

14. An apparatus for cooling hot gases in a reactor (10, 210) which is provided with a hot gas inlet duct and a chamber encompassing a bubbling fluidized bed (11, 211, 311) in the lower section of the reactor, a riser (14, 214) in the middle section, and a gas outlet (18, 218) in the upper section of the reactor,
characterized in that the reactor comprises
   - a preseparation chamber (30, 231) arranged above the fluidized bed,
   - a mixing chamber (11) arranged in the lower section of the reactor, below the riser, for mixing gas with solids,
   - at least one particle separator (17, 217),
   - at least one return duct (21, 221) for returning the particles separated in the particle separator (17, 217) to the lower section of the reactor, and
   - heat transfer surfaces (27, 227) arranged in the return fluidized bed.

15. An apparatus as recited in claim 14, **characterized in that** it comprises means (28, 328) for conveying solid particles from the lower portion of the bubbling fluidized bed (11, 211, 311) into the mixing chamber (12, 212, 312).

16. An apparatus as recited in claim 14, **characterized in that** the cross section of the mixing chamber (12, 212, 312) is at least partly upwardly widening ?

17. An apparatus as recited in claim 14, **characterized in that** the mixing chamber is conical.

18. An apparatus as recited in claim 14, **characterized in that** the upper section of the chamber provided with the bubbling fluidized bed (11) has the shape of an open vat.

19. An apparatus as recited in claim 14, **characterized in that** the bubbling fluidized bed (14) is arranged in an annular chamber encircling the mixing chamber.

20. An apparatus as recited in claim 14, **characterized in that** the return duct (21) for solids forms a narrow slot-shaped space.

21. An apparatus as recited in claim 14, **characterized in that** the return duct (21) is structurally integrated with the riser so that the riser wall constitutes part of the return duct wall.

22. An apparatus as recited in claim 14, **characterized in that** the return duct is provided with heat transfer surfaces (26).

23. An apparatus as recited in claim 14, **characterized in that** the return duct is provided with means (22, 222) for conveying solid material into either the mixing chamber or the fluidized bed.

24. An apparatus as recited in claim 14, **characterized in that** the gas mixing chamber (312) rectangular in shape, in which mixing chamber at least one of the two opposite walls is outwardly inclined when seen from bottom to top, and that the bubbling fluidized bed (311) is arranged in an elongated chamber which has an open top and which is disposed adjacent to the mixing chamber.

25. An apparatus as recited in claim 14, **characterized in that** the bubbling fluidized bed is provided with gas-regulated means (28, 228, 328) for conveying solid particles from the bed through the openings into the mixing chamber.

26. An apparatus as recited in claim 14, **characterized in that** the wall between the fluidized and the mixing chamber comprises a heat transfer surface for recovering heat from the

hot gases.

27. An apparatus as recited in claim 14, **characterized in that** the particle separator (17, 217) is arranged in the upper section of the riser and connected with the riser (22) by a common wall construction.

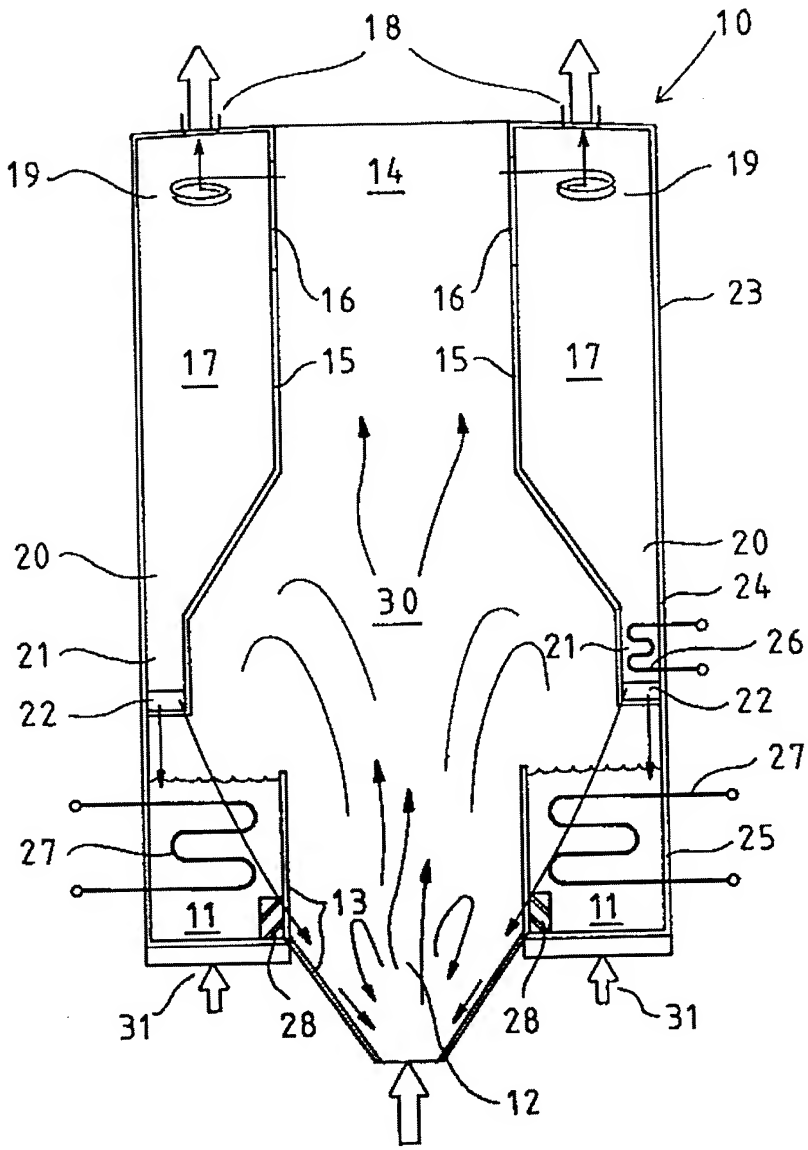
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FIG. 1

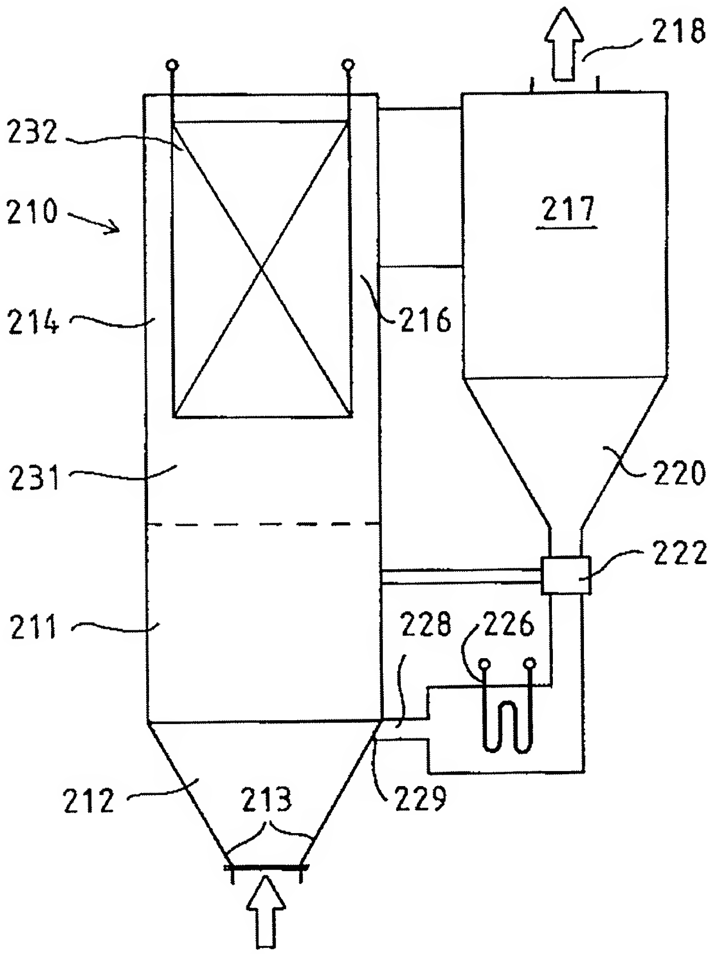
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FIG. 2

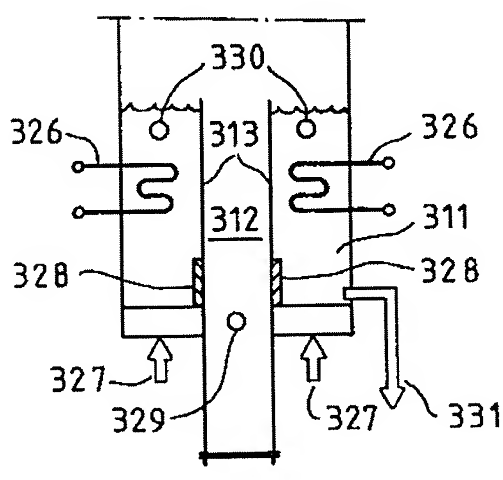
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FIG. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 10 9724

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	EP-A-0 094 795 (EXXON)		B01J8/38 F28D13/00 F22B31/00 F28C3/16
A	EP-A-0 282 777 (L & C STEINMÜLLER)		
A	GB-A-796 914 (ESSO)		
A,D	FI-A-913 416 (METALLGESELLSCHAFT)		

TECHNICAL FIELDS SEARCHED (Int.Cl.5)
B01J F28D F22B F28C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 September 1994	Meertens, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document